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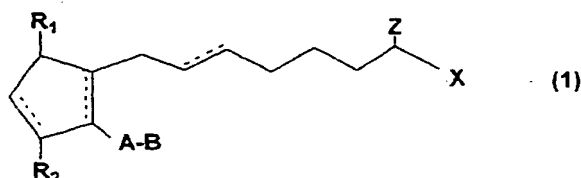
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(54) Title: METHOD OF ENHANCING HAIR GROWTH



(57) Abstract: Methods and compositions for stimulating the growth of hair are disclosed wherein said compositions include a cyclopentane heptanoic, 2-cycloalkyl or arylalkyl compound represented by the formula (1) wherein the dashed bonds represent a single or double bond which can be in the cis or trans configuration, A, B, Z, X R<sub>1</sub> and R<sub>2</sub> as defined in the specification. Such compositions are used in treating the skin or scalp of a human or non-human animal. Bimatoprost is preferred for this treatment.

WO 03/066008 A1

## METHOD OF ENHANCING HAIR GROWTH

RELATED APPLICATIONS

This application is based on, and claims the benefit of, U.S. Provisional Application No. 60/354,425, filed February 4, 2002 and which is incorporated herein by reference.

## 1. FIELD OF THE INVENTION

This invention relates to a method for stimulating the growth of mammalian hair comprising the application to mammalian skin of a cyclopentane heptanoic acid, 2-cycloalkyl or arylalkyl derivative or a pharmacologically acceptable acid addition salt thereof, alone, or in association with a topical pharmaceutical carrier.

## 2. BACKGROUND OF THE INVENTION

Dermatologists recognize many different types of hair loss, the most common by far being "alopecia" wherein human males begin losing scalp hair at the temples and on the crown of the head as they get older. While this type of hair loss is largely confined to males, hence its common name "male pattern baldness," it is not unknown in women. No known cure has yet been found despite continuing attempts to discover one.

A good deal is known about various types of human hair and its growth patterns on various parts of the body.

For purposes of the present invention, it is necessary to consider various types of hair, including, terminal hairs and vellus hairs and modified terminal hairs, such as seen in eye lashes and eye brows. Terminal hairs are coarse, pigmented, long hairs in which the bulb of the hair follicle is seated deep in the dermis. Vellus hairs, on the other hand, are fine, thin, non-pigmented short hairs in

which the hair bulb is located superficially in the dermis. As alopecia progresses, a transition takes place in the area of approaching baldness wherein the hairs themselves are changing from the terminal to the vellus type.

Another factor that contributes to the end result is a change in the cycle of hair growth. All hair, both human and animal, passes through a life cycle that includes three phases, namely, the anagen phase, the catagen phase and the telogen phase. The anagen phase is the period of active hair growth and, insofar as scalp hair is concerned, this generally lasts from 3-5 years. The catagen phase is a short transitional phase between the anagen and telogen phases which, in the case of scalp hair, lasts only 1-2 weeks. The final phase is the telogen phase which, for all practical purposes, can be denominated a "resting phase" where all growth ceases and the hair eventually is shed preparatory to the follicle commencing to grow a new one. Scalp hair in the telogen phase is also relatively short-lived, some 3-4 months elapsing before the hair is shed and a new one begins to grow.

Under normal hair growth conditions on the scalp, approximately 88% of the hairs are in the anagen phase, only 1% in catagen and the remainder in telogen. With the onset of male pattern baldness, a successively greater proportion of the hairs are in the telogen phase with correspondingly fewer in the active growth anagen phase.

Alopecia is associated with the severe diminution of hair follicles. A bald human subject will average only about 306 follicles per square centimeter, whereas, a non-bald human in the same age group will have an average of 460 follicles per square centimeter. This amounts to a one-third reduction in hair follicles which, when added to the increased proportion of vellus hair follicles and the increased number of hair follicles in the telogen phase, is both significant and noticeable. Approximately 50% of the hairs must be shed to produce visible thinning of scalp hair. It is thus a combination of these factors: transition of hairs from terminal to vellus, increased number of telogen hairs--some of which have been shed, and loss of hair follicles that produces "baldness".

While a good deal is known about the results of male pattern baldness, very little is known about its cause. The cause is generally believed to be genetic and

hormonal in origin although, the known prior art attempts to control it through hormone adjustment have been singularly unsuccessful.

One known treatment for male pattern alopecia is hair transplantation. Plugs of skin containing hair are transplanted from areas of the scalp where hair is growing to bald areas with reasonable success; however, the procedure is a costly one in addition to being time-consuming and quite painful. Furthermore, the solution is inadequate from the standpoint that it becomes a practical, if not an economic, impossibility to replace but a tiny fraction of the hair present in a normal healthy head of hair.

Other non-drug related approaches to the problem include such things as ultra-violet radiation, massage, psychiatric treatment and exercise therapy. None of these, however, has been generally accepted as being effective. Even such things as revascularization surgery and acupuncture have shown little, if any, promise.

By far, the most common approach to the problem of discovering a remedy for hair loss and male pattern alopecia has been one of drug therapy. Many types of drugs ranging from vitamins to hormones have been tried and only recently has there been any indication whatsoever of even moderate success. For instance, it was felt for a long time that since an androgenic hormone was necessary for the development of male pattern baldness, that either systemic or topical application of an antiandrogenic hormone would provide the necessary inhibiting action to keep the baldness from occurring. The theory was promising but the results were uniformly disappointing.

The androgenic hormone testosterone was known, for example, to stimulate hair growth when applied topically to the deltoid area as well as when injected into the beard and pubic regions. Even oral administration was found to result in an increased hair growth in the beard and pubic areas as well as upon the trunk and extremities. While topical application to the arm causes increased hair growth, it is ineffective on the scalp and some thinning may even result. Heavy doses of testosterone have even been known to cause male pattern alopecia.

Certain therapeutic agents have been known to induce hair growth in extensive areas of the trunk, limbs and even occasionally on the face. Such hair is

of intermediate status in that it is coarser than vellus but not as coarse as terminal hair. The hair is generally quite short with a length of 3 cm. being about maximum. Once the patient ceases taking the drug, the hair reverts to whatever is normal for the particular site after six months to a year has elapsed. An example of such a drug is diphenylhydantoin which is an anticonvulsant drug widely used to control epileptic seizures. Hypertrichosis is frequently observed in epileptic children some two or three months after starting the drug and first becomes noticeable on the extensor aspects of the limbs and later on the trunk and face. (The same pattern of hypertrichosis is sometimes caused by injury to the head.) As for the hair, it is often shed when the drug is discontinued but may, in some circumstances, remain.

Streptomycin is another drug that has been found to produce hypertrichosis, in much the same way as diphenylhydantoin, when administered to children suffering from tuberculous meningitis. About the same effects were observed and the onset and reversal of the hypertrichosis in relation to the period of treatment with the antibiotic leave little question but that it was the causative agent.

Two treatments have been demonstrated as showing some promise in reversing male pattern alopecia. These treatments include the use of a microemulsion cream containing both estradiol and oxandrolone as its active ingredients and the use of organic silicon.

In addition to the foregoing, it has been reported in U.S. Pat. Nos. 4,139,619 and 4,968,812 that the compound minoxidil is useful for the treatment of male pattern baldness. That compound, among others, has proven to have considerable therapeutic value in the treatment of severe hypertension. It is a so-called "vasodilator" which, as the name implies, functions to dilate the peripheral vascular system. Dermatologists and others have recognized that prolonged vasodilation of certain areas of the human body other than the scalp sometimes result in increased hair growth even in the absence of any vasodilating therapeutic agent. For instance, increased hair growth around surgical scars is not uncommon. Similarly, arteriovenous fistula have been known to result in increased vascularity

accompanied by enhanced hair growth. Externally-induced vasodilation of the skin, such as, for example, by repeated biting of the limbs by the mentally retarded and localized stimulation of the shoulders by water carries has been known to bring on hypertrichosis in the affected areas. Be that as it may, similar techniques such as continued periodic massage of the scalp have been found to be totally ineffective as a means for restoring lost hair growth to the scalp. Scar tissue on the scalp inhibits rather than promotes hair growth.

U.S. Patent Number 6,262,105 to Johnstone suggests that prostaglandins and derivatives thereof are useful in a method of enhancing hair growth.

Bimatoprost, which is sold by Allergan, Inc. of Irvine, California, U.S.A. as Lumigan® ophthalmic solution, for treating glaucoma now has been found as being effective to increase the growth of eyelashes when applied in the FDA approved manner.

It is, therefore, a principal object of the present invention to provide a novel and effective treatment for the stimulation of hair growth and the treatment of male pattern baldness.

Another object of the invention is to provide a method of stimulating hair growth in humans and non-human animals that is compatible with various types of therapeutic agents or carriers and, therefore, would appear to be combinable with those which, by themselves, demonstrate some therapeutic activity such as, for example, microemulsion creams or topical compositions containing estradiol and oxandrolone, minoxidil or agents that block the conversion of testosterone to dihydrotestosterone (Procipia).

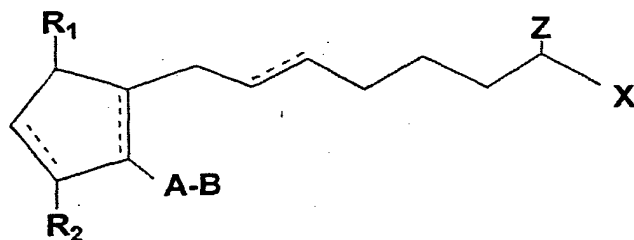
Still another objective is the provision of a treatment for the stimulation of hair growth which, while effective for its intended purpose, is apparently non-toxic and relatively free of unwanted side effects.

An additional object of the invention herein disclosed and claimed is to provide a method for treating hair loss in men or women which can be applied by the patient under medical supervision no more stringent than that demanded for other topically-administered therapeutic agents.

Other objects of the invention are to provide a treatment for male pattern alopecia which is safe, simple, painless, cosmetic in the sense of being invisible; easy to apply and quite inexpensive when compared with hair transplants and the like.

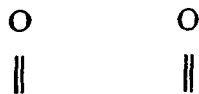
## SUMMARY OF THE INVENTION

This invention provides pharmaceutical compositions for topical application to enhance hair growth comprising an effective amount of a cyclopentane heptanoic acid, 2-cycloalkyl or arylalkyl compound represented by the formula I



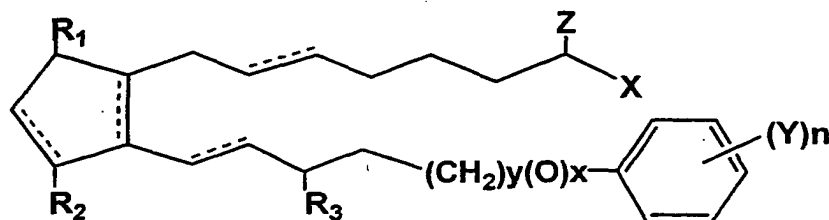
wherein the dashed bonds represent a single or double bond which can be in the cis or trans configuration, A is an alkylene or alkenylene radical having from two to six carbon atoms, which radical may be interrupted by one or more oxa radicals and substituted with one or more hydroxy, oxo, alkyloxy or alkylcarboxy groups wherein said alkyl radical comprises from one to six carbon atoms; B is a cycloalkyl radical having from three to seven carbon atoms, or an aryl radical, selected from the group consisting of hydrocarbyl aryl and heteroaryl radicals having from four to ten carbon atoms wherein the heteroatom is selected from the group consisting of nitrogen, oxygen and sulfur atoms; X is -N(R<sup>4</sup>)<sub>2</sub> wherein R<sup>4</sup> is selected from the group consisting of hydrogen, a lower alkyl radical having from one to six carbon atoms,

7



$\text{R}^5\text{-C-}$  and  $\text{R}^5\text{-O-C-}$  wherein  $\text{R}^5$  is a lower alkyl radical having from one to six carbon atoms;  $\text{Z}$  is  $=\text{O}$ ; one of  $\text{R}_1$  and  $\text{R}_2$  is  $=\text{O}$ ,  $-\text{OH}$  or a  $-\text{O}(\text{CO})\text{R}_6$  group, and the other one is  $-\text{OH}$  or  $-\text{O}(\text{CO})\text{R}_6$ , or  $\text{R}_1$  is  $=\text{O}$  and  $\text{R}_2$  is  $\text{H}$ , wherein  $\text{R}_6$  is a saturated or unsaturated acyclic hydrocarbon group having from 1 to about 20 carbon atoms, or  $-(\text{CH}_2)_m\text{R}_7$  wherein  $m$  is 0 or an integer of from 1 to 10, and  $\text{R}_7$  is cycloalkyl radical, having from three to seven carbon atoms, or a hydrocarbyl aryl or heteroaryl radical, as defined above in free form or a pharmaceutically acceptable salt thereof, in association with a pharmaceutical carrier adapted for topical application to mammalian skin.

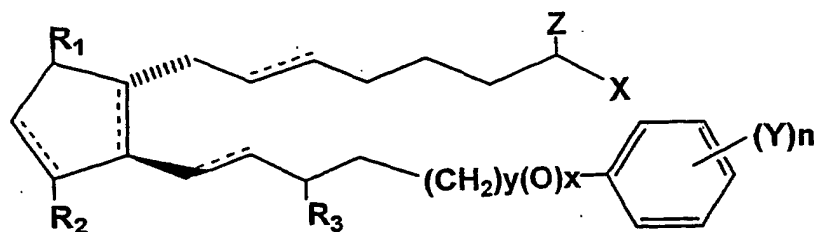
Preferably, the compound is a cyclopentane heptanoic acid, 2-(phenyl alkyl or phenyloxyalkyl) represented by the formula II



wherein  $y$  is 0 or 1,  $x$  is 0 or 1 and  $x$  and  $y$  are not both 1,  $\text{Y}$  is a radical selected from the group consisting of alkyl, halo, e.g. fluoro, chloro, etc., nitro, amino, thiol, hydroxy, alkyloxy, alkylcarboxy, halo substituted alkyl wherein said alkyl radical comprises from one to six carbon atoms, etc. and  $n$  is 0 or an integer of from 1 to 3 and  $\text{R}_3$  is  $=\text{O}$ ,  $-\text{OH}$  or  $-\text{O}(\text{CO})\text{R}_6$  wherein  $\text{R}_6$  is as defined above or a pharmaceutically acceptable salt thereof.

More preferably the compound is a compound of formula III.



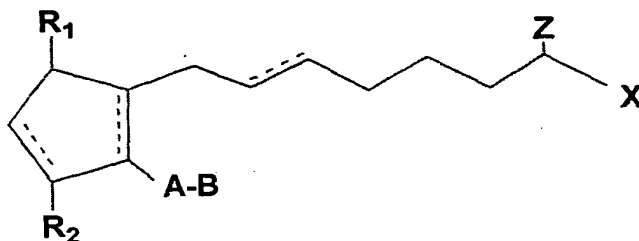


wherein hatched lines indicate  $\alpha$  configuration, solid triangles are used to indicate  $\beta$  configuration.

More preferably  $y$  is 1 and  $x$  is 0 and  $R_1$ ,  $R_2$  and  $R_3$  are hydroxy.

Most preferably the compound is cyclopentane N-ethyl heptanamide-5-cis-2-(3 $\alpha$ -hydroxy-5-phenyl-1-trans-pentenyl)-3,5-dihydroxy,  $[1_{\alpha}, 2_{\beta}, 3_{\alpha}, 5_{\alpha}]$ , also known as bimatoprost.

Another aspect of the invention provides methods for stimulating the rate of hair growth and for stimulating the conversion of vellus hair or intermediate hair to growth as terminal hair in a human or non-human animal by administering to the skin of the animal an effective amount of a compound wherein the compound has the formula:



wherein the dashed bonds represent a single or double bond which can be in the cis or trans configuration, A is an alkylene or alkenylene radical having from two to six carbon atoms, which radical may be interrupted by one or more oxa radicals and substituted with one or more hydroxy, oxo, alkyloxy or alkylcarboxy groups wherein said alkyl radical comprises from one to six carbon atoms; B is a cycloalkyl radical having from three to seven carbon atoms, or an aryl radical,

selected from the group consisting of hydrocarbyl aryl and heteroaryl radicals having from four to ten carbon atoms wherein the heteroatom is selected from the group consisting of nitrogen, oxygen and sulfur atoms; X is  $-N(R^4)_2$  wherein  $R^4$  is selected from the group consisting of hydrogen, a lower alkyl radical having from one to six carbon atoms,



$R^5-C-$  and  $R^5-O-C-$  wherein  $R^5$  is a lower alkyl radical having from one to six carbon atoms; Z is  $=O$ ; one of  $R_1$  and  $R_2$  is  $=O$ ,  $-OH$  or a  $-O(CO)R_6$  group, and the other one is  $-OH$  or  $-O(CO)R_6$ , or  $R_1$  is  $=O$  and  $R_2$  is H, wherein  $R_6$  is a saturated or unsaturated acyclic hydrocarbon group having from 1 to about 20 carbon atoms, or  $-(CH_2)_mR_7$  wherein m is 0 or an integer of from 1 to 10, and  $R_7$  is cycloalkyl radical, having from three to seven carbon atoms, or a hydrocarbyl aryl or heteroaryl radical, as defined above in free form or a pharmaceutically acceptable salt thereof.

These and other aspects of the invention will become apparent from the description of the invention which follows below.

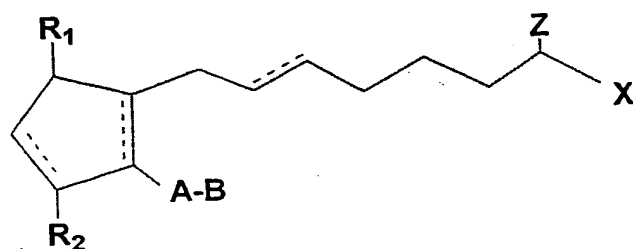
## BRIEF DESCRIPTION OF THE DRAWING FIGURE

The Figure shows the effect on the eyelashes of one patient treated for glaucoma with Lumigan® bimatoprost for six months.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Alopecia (baldness) a deficiency of either normal or abnormal hair, is primarily a cosmetic problem in humans. It is a deficiency of terminal hair, the broad diameter, colored hair that is readily seen. However, in the so-called bald person although there is a noticeable absence of terminal hair, the skin does contain vellus hair which is a fine colorless hair which may require microscopic

examination to determine its presence. This vellus hair is a precursor to terminal hair. In accordance with the invention as described herein, compounds represented by



wherein  $R_1$ ,  $R_2$ , A, B, Z and X are defined above, can be used to stimulate, such as stimulating the conversion of vellus hair to growth as terminal hair as well as increasing the rate of growth of terminal hair.

The present invention was discovered as follows:

In the course of treating patients having glaucoma, treatment may only be appropriate in one eye. Within the course of daily practice it was discovered that a patient who been treated with bimatoprost has lashes that were longer, thicker and fuller in the treated eye than in the non-treated eye. On examination the difference was found to be very striking. The lashes were longer and had a more full dense appearance in the treated eye. The lash appearance on the lids of the treated eye would have appeared quite attractive if it represented a bilateral phenomenon. Because of its asymmetric nature, the long lashes on one side could be construed as disturbing from a cosmetic standpoint. Because of the very unusual appearance a systematic examination of other patients who were taking bimatoprost in only one eye was made. It soon became apparent that this altered appearance was not an isolated finding. Comparison of the lids of patients who were taking bimatoprost in only one eye revealed subtle changes in the lashes and adjacent hairs of the bimatoprost-treated side in several patients. Definite differences could be identified to varying degrees in the lashes and adjacent hairs of all patients who were taking the drug on a unilateral basis for longer than 6 months.

These findings were totally unexpected and surprising. Minoxidil is thought to stimulate hair growth by its ability to cause vasodilation suggesting that agents with such a capability may be uniquely effective in stimulating hair growth. The finding that bimatoprost, which, as explained below, is not a prostaglandin derivative, such as latanoprost stimulates hair growth is especially surprising and unexpected.

The changes in the lashes were apparent on gross inspection in several patients once attention was focused on the issue. In those with light colored hair and lashes, the differences were only seen easily with the aid of the high magnification and lighting capabilities of the slit lamp biomicroscope. In the course of a glaucoma follow up examination, attention is generally immediately focused on the eye itself. Because of the high power magnification needed only one eye is seen at a time and the eye is seen at a high enough power that the lashes are not in focus. At these higher powers, any lash asymmetry between the two eyes is not likely to be noticed except by careful systematic comparison of the lashes and adjacent hairs of the eyelids of the two eyes.

Observed parameters leading to the conclusion that more robust hair growth occurred in the treated area following administration of bimatoprost were multiple. They included increased length of lashes, increased numbers of lashes along the normal lash line, increased thickness and luster of lashes, increased auxiliary lash-like terminal hair in transitional areas adjacent to areas of normal lash growth, increased lash-like terminal hairs at the medial and lateral canthal area, increased pigmentation of the lashes, increased numbers, increased length, as well as increased luster, and thickness of fine hair on the skin of the adjacent lid, and finally increased perpendicular angulation of lashes and lash-like terminal hairs. The conclusion that hair growth is stimulated by bimatoprost is thus supported not by evidence of a difference in a single parameter but is based on multiple parameters of hair appearance in treated vs. control areas in many subjects. This finding is entirely unexpected and represents a previously unrecognized effect of bimatoprost on stimulation of hair follicles. The modified hairs of the lashes normally turn over slowly and are in their resting phase longer

than hair on, for example, the scalp. The ability to cause differences in appearance of lashes, the ability to stimulate conversion of vellus or intermediate hair to terminal hairs in transitional areas and the ability to stimulate growth of vellus hair on the skin indicates that bimatoprost is a diversely effective and efficacious agent for the stimulation of hair growth. Thus, the present invention provides a treatment by bimatoprost of hair of the scalp, eyebrows, beard and other areas that contain hair that results in increased hair growth in the corresponding areas.

Patients that are treated in or around the eye with compounds of the invention, such as bimatoprost, regularly develop hypertrichosis including altered differentiation, numbers, length, thickness, curvature and pigmentation in the region of treatment.

Some examples of representative compounds useful in the practice of the present invention include the compounds shown in Table 1:

TABLE 1

cyclopentane heptenamide-5-cis-2-(3 $\alpha$ -hydroxy-5-phenyl-1-trans-pentenyl)-3, 5-dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

cyclopentane N,N-dimethylheptenamide-5-cis-2-(3 $\alpha$ -hydroxy-5-phenyl-1-trans-pentenyl)-3, 5-dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

cyclopentane heptenylamide-5-cis-2-(3 $\alpha$ -hydroxy-4-meta-chlorophenoxy-1-trans-pentenyl)-3, 5-dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

cyclopentane heptenylamide-5-cis-2-(3 $\alpha$ -hydroxy-4-trifluoromethylphenoxy-1-trans-pentenyl)-3, 5-dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

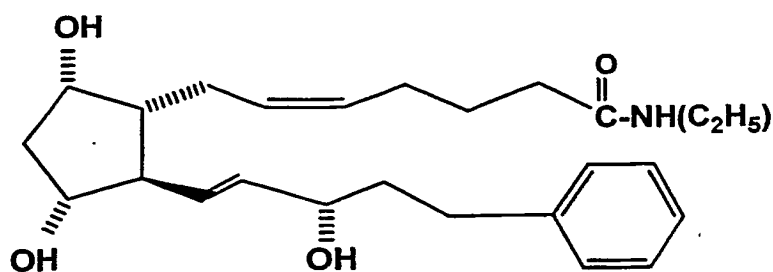
cyclopentane N-isopropyl heptenamide-5-cis-2-(3 $\alpha$ -hydroxy-5-phenyl-1-trans-pentenyl)-3, 5-dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

cyclopentane N-ethyl heptenamide-5-cis-2-(3 $\alpha$ -hydroxy-5-phenyl-1-trans-pentenyl)-3, 5 dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

cyclopentane N-methyl heptenamide-5-cis-2-(3 $\alpha$ -hydroxy-5-phenyl-1-trans-pentenyl)-3, 5-dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

cyclopentane heptenamide-5-cis-2-(3 $\alpha$ -hydroxy-4-meta-chlorophenoxy-1-trans-butenyl)-3, 5-dihydroxy, [1 $\alpha$ , 2 $\beta$ , 3 $\alpha$ , 5 $\alpha$ ]

One presently preferred compound for use in the practice of the present invention is cyclopentane N-ethyl heptenamide-5-cis-2-(3 $\alpha$ -hydroxy-5-phenyl-1-trans-pentenyl)-3,5-dihydroxy, [1 $\alpha$ ,2 $\beta$ ,3 $\alpha$ ,5 $\alpha$ ], also known as bimatoprost and sold under the name of Lumigan® by Allergan, Inc., California, USA. This compound has the following structure:



The synthesis of the above compounds described above has been disclosed in U.S. Patent No. 5,607,978. This patent also shows, particularly in Examples 1, 2, 5 and 7 that these compounds are not prostaglandins, in that they do not behave as prostaglandins in art-recognized assays for prostaglandin activity. The invention thus relates to the use of the above compounds, or prodrugs of the active compounds, for treatment for the stimulation of hair growth. As used herein, hair

growth includes hair associated with the scalp, eyebrows, eyelids, beard, and other areas of the skin of animals.

In accordance with one aspect of the invention, the compound is mixed with a dermatologically compatible vehicle or carrier. The vehicle which may be employed for preparing compositions of this invention may comprise, for example, aqueous solutions such as e.g., physiological salines, oil solutions or ointments. The vehicle furthermore may contain dermatologically compatible preservatives such as e.g., benzalkonium chloride, surfactants like e.g., polysorbate 80, liposomes or polymers, for example, methyl cellulose, polyvinyl alcohol, polyvinyl pyrrolidone and hyaluronic acid; these may be used for increasing the viscosity. Furthermore, it is also possible to use soluble or insoluble drug inserts when the drug is to be administered.

The invention is also related to dermatological compositions for topical treatment for the stimulation of hair growth which comprise an effective hair growth stimulating amount of one or more compounds as defined above and a dermatologically compatible carrier. Effective amounts of the active compounds may be determined by one of ordinary skill in the art but will vary depending on the compound employed, frequency of application and desired result, and the compound will generally range from about 0.0000001 to about 50%, by weight, of the dermatological composition, preferably from about 0.001 to about 50%, by weight, of total dermatological composition, more preferably from about 0.1 to about 30%, by weight of the composition.

The present invention finds application in all mammalian species, including both humans and animals. In humans, the compounds of the subject invention can be applied for example, to the scalp, face, beard, head, pubic area, upper lip, eyebrows, and eyelids. In animals raised for their pelts, e.g., mink, the compounds can be applied over the entire surface of the body to improve the overall pelt for commercial reasons. The process can also be used for cosmetic reasons in animals, e.g., applied to the skin of dogs and cats having bald patches due to mange or other diseases causing a degree of alopecia.

The pharmaceutical compositions contemplated by this invention include pharmaceutical compositions suited for topical and local action.

The term "topical" as employed herein relates to the use of a compound, as described herein, incorporated in a suitable pharmaceutical carrier, and applied at the site of thinning hair or baldness for exertion of local action. Accordingly, such topical compositions include those pharmaceutical forms in which the compound is applied externally by direct contact with the skin surface to be treated.

Conventional pharmaceutical forms for this purpose include ointments, liniments, creams, shampoos, lotions, pastes, jellies, sprays, aerosols, and the like, and may be applied in patches or impregnated dressings depending on the part of the body to be treated. The term "ointment" embraces formulations (including creams) having oleaginous, water-soluble and emulsion-type bases, e.g., petrolatum, lanolin, polyethylene glycols, as well as mixtures of these.

Typically, the compounds are applied repeatedly for a sustained period of time topically on the part of the body to be treated, for example, the eyelids, eyebrows, skin or scalp. The preferred dosage regimen will generally involve regular, such as daily, administration for a period of treatment of at least one month, more preferably at least three months, and most preferably at least six months.

For topical use on the eyelids or eyebrows, the active compounds can be formulated in aqueous solutions, creams, ointments or oils exhibiting physiologically acceptable osmolarity by addition of pharmacologically acceptable buffers and salts. Such formulations may or may not, depending on the dispenser, contain preservatives such as benzalkonium chloride, chlorhexidine, chlorobutanol, parahydroxybenzoic acids and phenylmercuric salts such as nitrate, chloride, acetate, and borate, or antioxidants, as well as additives like EDTA, sorbitol, boric acid etc. as additives. Furthermore, particularly aqueous solutions may contain viscosity increasing agents such as polysaccharides, e.g., methylcellulose, mucopolysaccharides, e.g., hyaluronic acid and chondroitin sulfate, or polyalcohol, e.g., polyvinylalcohol. Various slow releasing gels and matrices may also be employed as well as soluble and insoluble ocular inserts,



for instance, based on substances forming in-situ gels. Depending on the actual formulation and compound to be used, various amounts of the drug and different dose regimens may be employed. Typically, the daily amount of compound for treatment of the eyelid may be about 0.1 ng to about 100 mg per eyelid.

For topical use on the skin and the scalp, the compound can be advantageously formulated using ointments, creams, liniments or patches as a carrier of the active ingredient. Also, these formulations may or may not contain preservatives, depending on the dispenser and nature of use. Such preservatives include those mentioned above, and methyl-, propyl-, or butyl-parahydroxybenzoic acid, betain, chlorhexidine, benzalkonium chloride, and the like. Various matrices for slow release delivery may also be used. Typically, the dose to be applied on the scalp is in the range of about 0.1 ng to about 100 mg per day, more preferably about 1 ng to about 10 mg per day, and most preferably about 10 ng to about 1 mg per day depending on the compound and the formulation. To achieve the daily amount of medication depending on the formulation, the compound may be administered once or several times daily with or without antioxidants.

The invention is further illustrated by the following non-limiting examples:

#### Example 1

##### In Vivo Treatment

A study is initiated to systematically evaluate the appearance of lashes and hair around the eyes of patients who are administering bimatoprost in only one eye. The study involves 10 subjects, 5 male, 5 female, average age 70 years, (ranging from 50-94 years). All patients have glaucoma. Each subject is treated daily by the topical application of one drop of bimatoprost at a dosage of 1.5  $\mu\text{g/ml/eye/day}$  (0.03%, by weight, ophthalmic solution, sold under the name Lumigan® by Allergan, Irvine, California, U.S.A.) to the region of one eye by instilling the drop onto the surface of the eye. The region of the fellow control eye is not treated with bimatoprost and served as a control.

In the course of treatment with eye drops, there is typically spontaneous tearing, and excess fluid from the drops and associated tears gathers at the lid margins. In the course of wiping the drug containing fluid from the lid margins and adjacent lid, a thin film of the fluid is routinely spread to contact the adjacent skin of the lid area. This widespread exposure of the skin around the lid to the effect of drops is regularly demonstrated in patients who develop a contact dermatitis. Typically the entire area of the upper and lower lid are involved with induration, erythema and edema demonstrating the regular extensive exposure of the ocular adnexa to the influence of topically applied drugs.

The study is limited to subjects who have administered bimatoprost to one eye for more than 3 months. The mean duration of exposure to bimatoprost prior to assessing the parameter of lash growth between the control and study eye is 129 days (range 90-254 days). Observations are made under high magnification at the slit lamp biomicroscope. Documentation of differences between the control and treatment areas is accomplished using a camera specially adapted for use with the slit lamp biomicroscope.

The results of the observations are as follows:

**Length of lashes:** Increased length of eyelashes is regularly observed on the side treated with bimatoprost. The difference in length varies from approximately 10% to as much as 30%.

**Number of lashes:** Increased numbers of lashes are observed in the treated eye of each patient. In areas where there are a large number of lashes in the control eye, the increased number of lashes in the bimatoprost-treated eye gave the lashes on the treated side a more thickly matted overall appearance.

**Auxiliary lash-like hair growth:** Several patients have an apparent increase in lash-like hair in transitional areas adjacent to areas of normal lash distribution. These prominent robust appear lash-like hairs appeared to be of comparable length to the

actual lashes. These long, thick lash-like hairs were present in the central portion of the lids of several patients in a linear arrangement just above the lash line. Hairs are present at similar locations in the control eyes but are by contrast thinner or more fine in appearance, have less luster and pigment and are more flat against the skin of the lid typical of vellus or intermediate hairs. In several patients, lash-like terminal hairs grow luxuriantly in the medial canthal area in the treated eye. In the corresponding control eye, vellus hairs are seen at the same location. Lash-like hairs are also present in the lateral canthal area of the treated eye but not the control eye in several subjects. Large lashes are not normally present at the lateral canthus and the area is generally free of all but a few occasional very fine lashes or vellus hairs.

Increased growth of vellus hair on lids: Fine microscopic vellus hair is present on the skin of the lids and is easily seen with the slit lamp biomicroscope. This vellus hair is typically denser adjacent to and below the lateral portion of the lower lids. While remaining microscopic, vellus hairs are increased in number, appear more robust and are much longer and thicker in treated than in control eyes in the areas below and lateral to the lower lid.

Perpendicular angulation of hairs: In areas where there are lash-like hairs above the lash line and in the medial and lateral canthal areas, the hairs are much longer, thicker and heavier. They also leave the surface of the skin at a more acute angle, as though they are stiffer or held in a more erect position by more robust follicles. This greater incline, pitch, rise or perpendicular angulation from the skin surface gives the appearance of greater density of the hairs.

The foregoing observations clearly establish that bimatoprost can be used to increase the growth of hair in man. This conclusion is based on the regular and consistent finding of manifestations of increased hair growth in treated vs. control areas in human subjects. The conclusion that the drug bimatoprost is capable of inducing increased robust growth of hair is based not on a single parameter, i.e., length, but is based on multiple lines of evidence as described in the results.

Detailed examination and description of multiple parameters of differences in hair is greatly facilitated by the ability to examine the hairs at high magnification under stable conditions of fixed focal length and subject position utilizing the capabilities of the slitlamp biomicroscope.

The Figure shows the actual results on the eyelashes of a patient treated for glaucoma with Lumigan® bimatoprost for 6 months.

### Example 2

#### Topical Cream

A topical cream is prepared as follows: Tegacid and spermaceti are melted together at a temperature of 70-80° C. Methylparaben is dissolved in about 500 gm of water and propylene glycol, polysorbate 80, and bimatoprost are added in turn, maintaining a temperature of 75-80° C. The methylparaben mixture is added slowly to the Tegacid and spermaceti melt, with constant stirring. The addition is continued for at least 30 minutes with additional stirring until the temperature has dropped to 40-45° C. Finally, sufficient water is added to bring the final weight to 1000 gm and the preparation stirred to maintain homogeneity until cooled and congealed.

### Example 3

#### Topical Cream

A topical cream is prepared as follows: Tegacid and spermaceti are melted together at a temperature of 70-80° C. Methylparaben is dissolved in water and propylene glycol, polysorbate 80, and bimatoprost are added in turn, maintaining a temperature of 75-80° C. The methylparaben mixture is added slowly to the Tegacid and spermaceti melt, with constant stirring. The addition is continued for at least 30 minutes with additional stirring until the temperature has dropped to 40-45° C. Finally, sufficient water is added to bring the final weight to 1000 gm and the preparation stirred to maintain homogeneity until cooled and congealed.

The composition is applied to bald human scalp once daily to stimulate the growth of hair.

#### Example 4

##### Topical Ointment

An ointment containing 2% by weight bimatoprost is prepared as follows:

White petrolatum and wool fat are melted, strained and liquid petrolatum is added thereto. The bimatoprost, zinc oxide, and calamine are added to the remaining liquid petrolatum and the mixture milled until the powders are finely divided and uniformly dispersed. The mixture is stirred into the white petrolatum, melted and cooled with stirring until the ointment congeals.

The foregoing ointment can be applied topically to mammalian skin for increased rate of hair growth, and can be prepared by omitting the zinc oxide and calamine.

#### Example 5

##### Ointment

A dermatological ophthalmic ointment containing 10% by weight bimatoprost is prepared by adding the active compound to light liquid petrolatum. White petrolatum is melted together with wool fat, strained, and the temperature adjusted to 45-50° C. The liquid petrolatum slurry is added and the ointment stirred until congealed. Suitably the ointment is packaged in 30 gm tubes.

The foregoing ointment can be applied to the eyelid to enhance the growth of eyelashes. Similarly the composition can be applied to the brow for eyebrow growth.

21

Example 6

## Solution

An aqueous solution containing 5%, by weight, bimatoprost is prepared as follows. Bimatoprost is dissolved in water and the resulting solution is sterilized by filtration. The solution is aseptically filled into sterile containers.

The composition so prepared can be used in the topical treatment of baldness by application to the scalp daily.

Example 7

## Lotion

A sample of bimatoprost is dissolved in the vehicle of N-methyl pyrrolidone and propylene glycol. The composition can be used for application to dogs or cats having hair loss due to mange or alopecia of other causes.

Example 8

## Aerosol

An aerosol containing approximately 0.1% by weight bimatoprost is prepared by dissolving the bimatoprost in absolute alcohol. The resulting solution filtered to remove particles and lint. This solution is chilled to about minus 30° C. To the solution is added a chilled mixture of dichlorodifluoromethane and dichlorotetrafluoroethane.

Thirteen ml plastic-coated amber bottles are cold filled with 11.5 gm each of the resulting solution and capped.

The composition can be sprayed on the scalp daily to stimulate the growth of hair.

Example 9

## Dusting Powder

A powder of the compound bimatoprost is prepared by mixing in dry form with talcum powder at a weight/weight ratio of 1:10. The powdered mixture is dusted on the fur of minks or other commercially valuable fur bearing animals and show animals for increased rate of hair growth.

Example 10

## Related Compounds

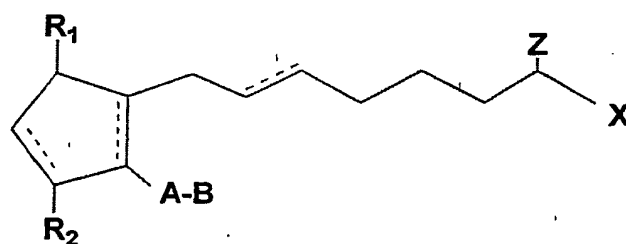
Following the procedure of the preceding Examples, compositions are similarly prepared substituting an equimolar amount of a compound of Table 1 for the bimatoprost disclosed in the preceding Examples. Similar results are obtained.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

## Claims:

1. A method for stimulating hair growth in a mammalian species comprising the application to mammalian skin of an effective amount of a cyclopentane heptanoic acid, 2-cycloalkyl or arylalkyl compound represented by the formula I

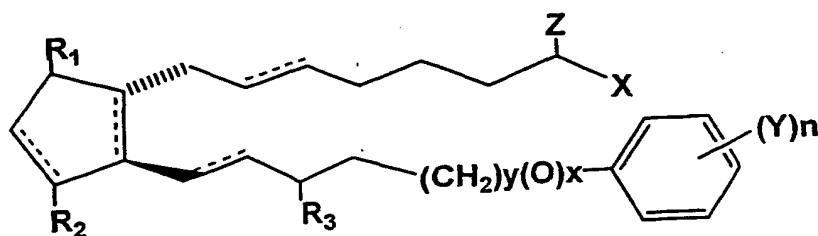


wherein the dashed bonds represent a single or double bond which can be in the cis or trans configuration, A is an alkylene or alkenylene radical having from two to six carbon atoms, which radical may be interrupted by one or more oxa radicals and substituted with one or more hydroxy, oxo, alkyloxy or alkylcarboxy groups wherein said alkyl radical comprises from one to six carbon atoms; B is a cycloalkyl radical having from three to seven carbon atoms, or an aryl radical, selected from the group consisting of hydrocarbyl aryl and heteroaryl radicals having from four to ten carbon atoms wherein the heteroatom is selected from the group consisting of nitrogen, oxygen and sulfur atoms; X is  $-N(R^4)_2$  wherein  $R^4$  is selected from the group consisting of hydrogen, a lower alkyl radical having from one to six carbon atoms,



$\begin{array}{c} \text{O} \\ \parallel \\ \text{R}^5\text{-C-} \end{array}$  and  $\begin{array}{c} \text{O} \\ \parallel \\ \text{R}^5\text{-O-C-} \end{array}$ , wherein  $\text{R}^5$  is a lower alkyl radical having from one to six carbon atoms;  $\text{Z}$  is  $=\text{O}$ ; one of  $\text{R}_1$  and  $\text{R}_2$  is  $=\text{O}$ ,  $-\text{OH}$  or a  $-\text{O}(\text{CO})\text{R}_6$  group, and the other one is  $-\text{OH}$  or  $-\text{O}(\text{CO})\text{R}_6$ ; or  $\text{R}_1$  is  $=\text{O}$  and  $\text{R}_2$  is  $\text{H}$ , wherein  $\text{R}_6$  is a saturated or unsaturated acyclic hydrocarbon group having from 1 to about 20 carbon atoms, or  $-(\text{CH}_2)_m\text{R}_7$  wherein  $m$  is 0 or an integer of from 1 to 10, and  $\text{R}_7$  is cycloalkyl radical, having from three to seven carbon atoms, or a hydrocarbyl aryl or heteroaryl radical, as defined above or a pharmacologically acceptable acid addition salt thereof.

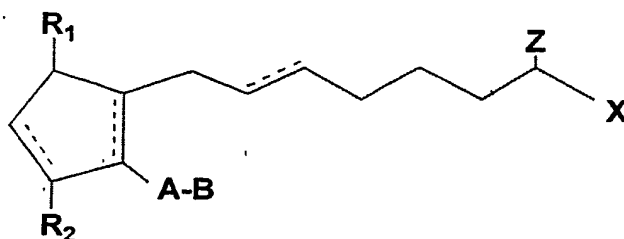
2. The method of claim 1 wherein the concentration of the compound applied is from about 0.0000001% to about 50% by weight of the composition.
3. The method of claim 1 wherein the compound is a compound of formula (III).



wherein  $y$  is 0 or 1,  $x$  is 0 or 1 and  $x$  and  $y$  are not both 1,  $\text{Y}$  is a radical selected from the group consisting of alkyl, halo, nitro, amino, thiol, hydroxy, alkyloxy, alkylcarboxy, halo substituted alkyl wherein said alkyl radical comprises from one to six carbon atoms,  $n$  is 0 or an integer of from 1 to about 3 and  $\text{R}_3$  is  $=\text{O}$ ,  $-\text{OH}$  or  $-\text{O}(\text{CO})\text{R}_6$  wherein  $\text{R}_6$ , hatched lines indicate  $\alpha$  configuration and solid triangles are used to indicate  $\beta$  configuration.

4. The method of claim 3 wherein the compound is bimatoprost or a pharmaceutically acceptable salt thereof

5. A method for the conversion of vellus hair or intermediate hair to growth as terminal hair comprising the application to mammalian skin at the locale of vellus hair of an effective amount of a cyclopentane heptanoic acid, 2-cycloalkyl or arylalkyl compound represented by the formula I



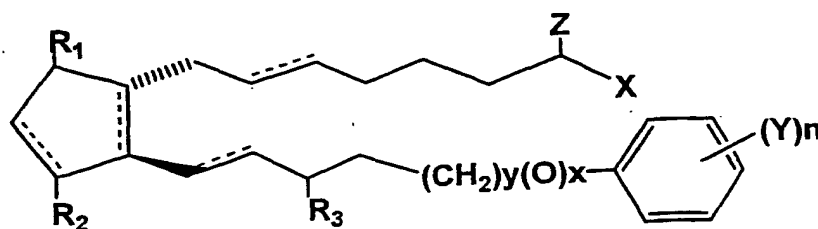
wherein the dashed bonds represent a single or double bond which can be in the cis or trans configuration, A is an alkylene or alkenylene radical having from two to six carbon atoms, which radical may be interrupted by one or more oxa radicals and substituted with one or more hydroxy, oxo, alkyloxy or alkylcarboxy groups wherein said alkyl radical comprises from one to six carbon atoms; B is a cycloalkyl radical having from three to seven carbon atoms, or an aryl radical, selected from the group consisting of hydrocarbyl aryl and heteroaryl radicals having from four to ten carbon atoms wherein the heteroatom is selected from the group consisting of nitrogen, oxygen and sulfur atoms; X is -N(R<sup>4</sup>)<sub>2</sub> wherein R<sup>4</sup> is selected from the group consisting of hydrogen, a lower alkyl radical having from one to six carbon atoms,



$\text{R}^5\text{-C-}$  and  $\text{R}^5\text{-O-C-}$ , wherein  $\text{R}^5$  is a lower alkyl radical having from one to six carbon atoms;  $\text{Z}$  is  $=\text{O}$ ; one of  $\text{R}_1$  and  $\text{R}_2$  is  $=\text{O}$ ,  $-\text{OH}$  or a  $-\text{O}(\text{CO})\text{R}_6$  group, and the other one is  $-\text{OH}$  or  $-\text{O}(\text{CO})\text{R}_6$ , or  $\text{R}_1$  is  $=\text{O}$  and  $\text{R}_2$  is  $\text{H}$ , wherein  $\text{R}_6$  is a saturated or unsaturated acyclic hydrocarbon group having from 1 to about 20 carbon atoms, or  $-(\text{CH}_2)_m\text{R}_7$  wherein  $m$  is 0 or an integer of from 1 to 10, and  $\text{R}_7$  is cycloalkyl radical, having from three to seven carbon atoms, or a hydrocarbyl aryl or heteroaryl radical, as defined above or a pharmacologically acceptable acid addition salt thereof.

6. The method of claim 5 wherein the concentration of the compound applied is from about 0.0000001% to about 50% by weight of the composition.

7. The method of claim 5 wherein the compound is a compound of formula (III).

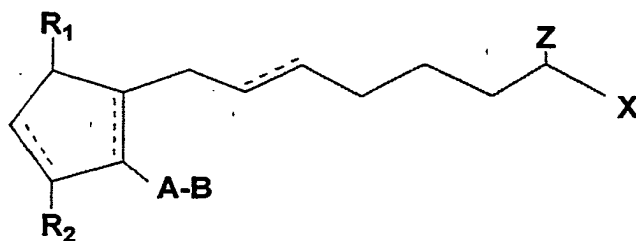


wherein  $y$  is 0 or 1,  $x$  is 0 or 1 and  $x$  and  $y$  are not both 1,  $\text{Y}$  is a radical selected from the group consisting of alkyl, halo, nitro, amino, thiol, hydroxy, alkyloxy, alkylcarboxy, halo substituted alkyl wherein said alkyl radical comprises from one to six carbon atoms,  $n$  is 0 or an integer of from 1 to about 3 and  $\text{R}_3$  is  $=\text{O}$ ,  $-\text{OH}$  or  $-\text{O}(\text{CO})\text{R}_6$ , hatched lines indicate  $\alpha$  configuration and solid triangles are used to indicate  $\beta$  configuration.

27

8. The method of claim 7 wherein the compound applied is bimatoprost in the form of the free base or acid addition salts thereof.

9. A method for stimulating hair follicles to increase hair growth and one or more properties selected from the group consisting of luster, sheen, brilliance, gloss, glow, shine or patina of hair associated with the follicles, comprising the application to mammalian skin at the locale of the follicles of an effective amount of a cyclopentane heptanoic acid, 2-cycloalkyl or arylalkyl compound represented by the formula I



wherein the dashed bonds represent a single or double bond which can be in the cis or trans configuration, A is an alkylene or alkenylene radical having from two to six carbon atoms, which radical may be interrupted by one or more oxide radicals and substituted with one or more hydroxy, oxo, alkyloxy or alkylcarboxy groups wherein said alkyl radical comprises from one to six carbon atoms; B is a cycloalkyl radical having from three to seven carbon atoms, or an aryl radical, selected from the group consisting of hydrocarbyl aryl and heteroaryl radicals having from four to ten carbon atoms wherein the heteroatom is selected from the group consisting of nitrogen, oxygen and sulfur atoms; X is -N(R<sup>4</sup>)<sub>2</sub> wherein R<sup>4</sup> is selected from the group consisting of hydrogen, a lower alkyl radical having from one to six carbon atoms,



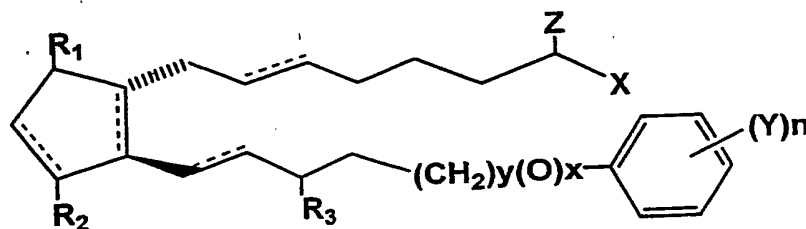
R<sup>5</sup>-C- and R<sup>5</sup>-O-C--, wherein R<sup>5</sup> is a lower alkyl radical having from one to six carbon atoms; Z is =O; one of R<sub>1</sub> and R<sub>2</sub> is =O, -OH or a -O(CO)R<sub>6</sub> group, and

28

the other one is -OH or -O(CO)R<sub>6</sub>, or R<sub>1</sub> is =O and R<sub>2</sub> is H, wherein R<sub>6</sub> is a saturated or unsaturated acyclic hydrocarbon group having from 1 to about 20 carbon atoms, or -(CH<sub>2</sub>)<sub>m</sub>R<sub>7</sub> wherein m is 0 or an integer of from 1 to 10, and R<sub>7</sub> is cycloalkyl radical, having from three to seven carbon atoms, or a hydrocarbyl aryl or heteroaryl radical, as defined above or a pharmacologically acceptable acid addition salt thereof.

10. The method of claim 1 wherein the concentration of the compound applied is from about 0.0000001% to about 50% by weight of the composition.

11. The method of claim 10 wherein the compound is a compound of formula (III).

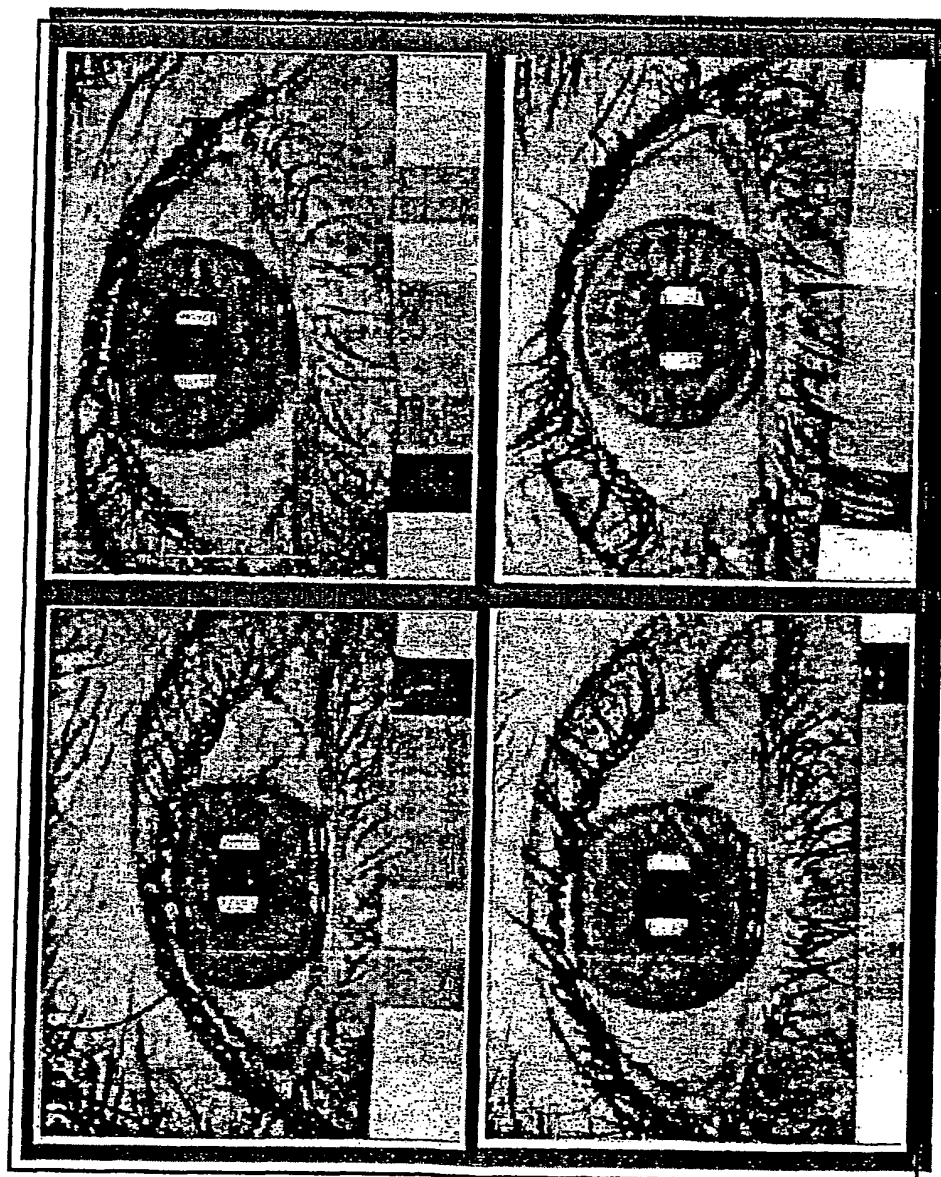


wherein y is 0 or 1, x is 0 or 1 and x and y are not both 1, Y is a radical selected from the group consisting of alkyl, halo, nitro, amino, thiol, hydroxy, alkyloxy, alkylcarboxy, halo substituted alkyl wherein said alkyl radical comprises from one to six carbon atoms, n is 0 or an integer of from 1 to about 3 and R<sub>3</sub> is =O, -OH or -O(CO)R<sub>6</sub> wherein R<sub>6</sub>, hatched lines indicate  $\alpha$  configuration and solid triangles are used to indicate  $\beta$  configuration.

12. The method of claim 11 wherein the compound is bimatoprost or a pharmaceutically acceptable salt.

# Eyelash Growth

OD OS



Baseline

Month 6

Figure 1

Best Available Copy

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 03/03363

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 A61K7/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)  
EPO-Internal, CHEM ABS Data, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	"Bimatoprost (Ophtalmic)" MEDLINEPLUS. HEALTH INFORMATION, 'Online! 24 July 2001 (2001-07-24), XP002245126 Retrieved from the Internet: <URL:www.nlm.nih.gov/medlineplus/druginfor/ /uspd/500295> 'retrieved on 2003-06-23! *see "Precautions while using this medicine" and "Side effects"	1-12
X	US 6 262 105 B1 (JOHNSTONE MURRAY A) 17 July 2001 (2001-07-17) column 7, line 55-65; claim 1; table 1	1-12
A	US 5 607 978 A (BURK ROBERT M ET AL) 4 March 1997 (1997-03-04) cited in the application the whole document	1-12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

23 June 2003

Date of mailing of the international search report

10/07/2003

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/03363

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